

Jet Propulsion Laboratory
California Institute of Technology

AFTA Coronagraph Recommendation: Plan Forward

Gary Blackwood, Exoplanet Exploration Program Manager

Kevin Grady, AFTA Study Office Manager

September 9, 2013



Approach to Recommendation

- Objective: Recommend a primary and backup coronagraph architecture to focus design and technology development leading to mid-decadal review and new mission start
- Recommendation by ExEPO and ASO based on inputs from
 - **SDT**: sets the science requirements
 - **ACWG**: delivers technical FOMs and technology plans
 - > *Aim for the positive: a consensus product*
 - > SDT delivers science FOMs
 - **TAC**: Analysis of technical FOM, TRL readiness plans, and risks
- ExEPO and ASO recommendation to APD based on:
 - Technical and Programmatic
 - Musts (Requirements), Wants (Goals), and Risks
 - Note: we distinguish description (*what*) from evaluation (*what do we care about? Discriminators, success criteria*)
- APD Director will make the decision

**ACWG =
representatives of
ExEPO, ASO, SDT,
Community**

**How do we define a
successful outcome?**

FOM = Figure of Merit

ACWG Membership



ExoPlanet Exploration Program

- These represent Program, Study Office, SDT, and Community:

Workshop Organizers:

Gary Blackwood (NASA JPL)
Kevin Grady (NASA GSFC)
Peter Lawson (NASA JPL)

Steering Group:

Chas Beichman (NExScI)
Scott Gaudi (OSU)
Neil Gehrels (NASA GSFC)
Tom Greene (NASA ARC)
Jeff Kruk (NASA GSFC)
Dave Spergel (Princeton U)
Karl Stapelfeldt (NASA GSFC)
Wes Traub (NASA JPL)
Bruce MacIntosh (LLNL)

General Members:

Mark Marley (NASA ARC)
Marc Clampin (NASA GSFC)
Olivier Guyon (UofA)
Gene Serabyn (NASA JPL)
Stuart Shaklan (NASA JPL)
Remi Soummer (STScI)
John Trauger (NASA JPL)
Marshall Perrin (STScI)
Feng Zhao (NASA JPL)
Rick Lyon (NASA GSFC)
Dave Content (NASA GSFC)
Mark Melton (NASA GSFC)
Cliff Jackson (NASA GSFC)
John Ruffa (NASA GSFC)
Jennifer Dooley (NASA JPL)
Mike Shao (NASA JPL)

- Additional consultants participate at request of Steering Group

Recommendation Criteria: (draft)

Defining a Successful Outcome



ExoPlanet Exploration Program

MUSTS (Requirements): *Go/No_Go*

1. Science: Does the proposed architecture meet the baseline science drivers?
2. Interfaces: For the baseline science, does the architecture meet the DCIL?¹
3. TRL Gates: For baseline science, is there a credible plan to be at TRL5 at the start of FY17 and at TRL6 at the start of FY19?

WANTS (Goals): *Relative to each other, for those that pass the Musts:*

1. Science:
 - a) Is there performance beyond the baseline?
2. Technical:
 - a) Relative demands on DCIL
 - b) Relative internal wavefront sensing and control
 - c) Relative TRL gap today for key technologies (reqt vs capability) wrt science baseline
 - d) When comparing each architecture:
 - i. Relative complexity
 - ii. Relative difficulty in alignment, calibration, and operations
3. Programmatic: Relative cost of plan to meet TRL Gates

RISKS *For those that pass the Musts:*

- Technical risk of instrument meeting the science requirement on-orbit
- Schedule risk to achieve the TRL Gates on time
- Potential cost risks to technology

¹DCL = Dave Content Interface List

Coronagraph Architectures for AFTA

- Six architectures are considered in ACWG:
 - Optical Design / Layout
 - Performance and Sensitivity Assessment
 - TRL Assessment (Current Level, and Plans)

Architecture 1: Shaped Pupil	Kasdin
Architecture 2: PIAA	Guyon / Belikov
Architecture 3: Band Limited Lyot Coronagraph	Trauger
Architecture 4: Vector Vortex	Serabyn
Architecture 5: VNC - DaVinci	Shao
Architecture 6: VNC - Phase-Occulted	Lyon

- Trade will focus on discriminators; will also consider factors that are common to all architectures (affect net science yield of any architecture)

	FY13			FY14			
	July	August	September	October	November	December	January
ACWG Events	ACW #1 at Princeton 23-25th			ACW #2 at JPL 9/25-27th	ACW #3 TBD Location 22-23rd	ACWG Final Briefing to TAC 11/6	
	Telecons 8/8 8/21 9/4			9/18 10/2	10/9 10/30	11/6	
	8/28			9/13			
SDT				ExoPAG at Denver 9-10th	Science FOM #1 10/2	Science FOM #2 10/30	
Baseline & Threshold Reqmts	SDT Meeting at GSFC 9/18			Draft 9/18	Prelim 9/30		
	8/23 Prelim			9/30	Final 9/30		
Advocates				9/25 Prelim	10/22 Final		
Optical Designs				9/25 Prelim	10/22 Final		
Technology Plans				9/30 Prelim	10/28 Final		
Coronagraph Instrument Team				9/25 Prelim	10/22 Final		
Simulations				9/30 Prelim	10/28 Final		
Sensitivities				9/25 Prelim	10/22 Final		
ExEPO Chief Technologist				9/25 Prelim	10/22 Final		
TRL Assessment				9/30 Prelim	10/28 Final		
TAC				10/2 Brief TAC	11/6 Brief TAC	Deliver Analysis to ExEPO & ASO	
ExEPO / ASO						12/4	
ExEPO/ASO Recommendations to APD						12/6	
Briefing to HQ						12/31	
HQ Decision						1/7 TBR	
P. Hertz Annoucement at AAS						1/7 TBR	
ExEPO/ASO Town Hall at AAS							

▽ Milestone

▼ Completed Milestone

◇ Review

◆ Completed Review

Glossary

ACWG - AFTA Coronagraph Working Group

ACW - AFTA Coronagraph Workshop

TFOM - Technical Figure of Merit

SFOM - Science Figure of Merit

TRL - Technology Readiness Level

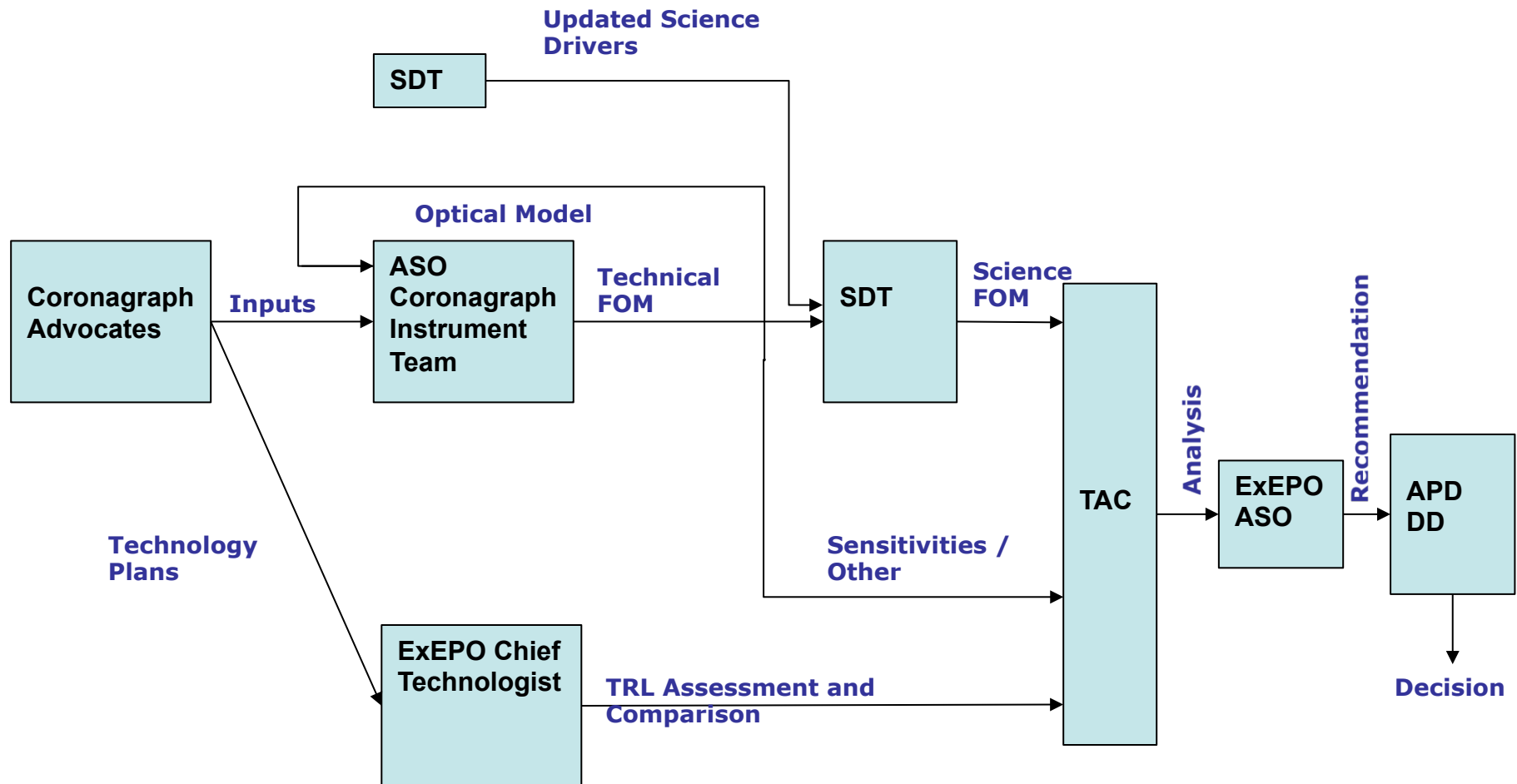
SDT - Science Definition Team

TAC - Technology Analysis Committee

Product of ACWG: Comparative Analysis

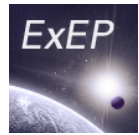


ExoPlanet Exploration Program



FOM = Figure of Merit
ASO = AFTA Study Office
ExEPO = Exoplanet Exploration Program Office

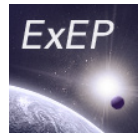
ACW#2 Agenda: 9/25-27, JPL



ExoPlanet Exploration Program

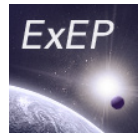
<u>Agenda Item (Day #1)</u>	<u>Presenter</u>	<u>Start</u>	<u>Duration</u>	<u>End</u>	<u>Topics to cover include:</u>
Visitor Control, Coffee, Pastries		7:15	0:45	8:00	
Introduction					
Center Welcome	Gallagher	8:00	0:05	8:05	
Workshop Introduction and Objectives	Blackwood, Grady	8:05	0:20	8:25	Process leading to Recommendation, Export, Status of actions. Decision process overview
HQs perspective	Hertz	8:25	0:20	8:45	
Updated trade matrix - part 1 of 2	Blackwood	8:45	0:15	9:00	
Status of inputs, products, and interfaces	Zhao	9:00	0:20	9:20	Reference Lawson, Krist memos, DCIL compliance
The AFTA pupil	Content/Dooley	9:20	0:15	9:35	Review what is used for ACWG, indicate future work
Break			0:20		
Designs for the AFTA pupil					
Option Description Summary	Zhao	9:55	0:20	10:15	Comparison table, context diagrams
Optical designs for the 5 architectures	Rud / Tang	10:15	0:45	11:00	Engineering results
Architecture 1: Shaped Pupil	Kasdin	11:00	0:40	11:40	Speak to optical design, and what done for AFTA pupil
Lunch		11:40	0:50	12:30	
Architecture 2: PIAA	Guyon / Belikov	12:30	0:40	13:10	
Architecture 3: Band Limited Lyot Coronagraph	Trauger	13:10	0:40	13:50	
Architecture 4: Vector Vortex	Serabyn	13:50	0:40	14:30	
Architecture 5: VNC - DaVinci	Shao	14:30	0:40	15:10	
Architecture 6: VNC - Phase-Occulted	Lyon	15:10	0:40	15:50	
Break			0:15		
Trade Products					
Analysis results for Architectures 1 and 2	Krist / Mennesson	16:05	0:55	17:00	Define TFOM, summarize, then go into detail
Reserve		17:00	0:30	17:30	
HCIT lab tour		16:05	1:00	17:05	

ACW#2 Agenda: 9/25-27, JPL



ExoPlanet Exploration Program

<u>Agenda Item (Day #2)</u>	<u>Presenter</u>	<u>Start</u>	<u>Duration</u>	<u>End</u>	
Visitor Control, Coffee, Pastries		7:45	0:30	8:15	
Analysis results for Architectures 3, 4, 5, 6	Krist / Mennesson	8:15	1:30	9:45	
Analysis summary & discussion	Zhao	9:45	0:30	10:15	Comparison tables
Break			0:20		
Breakout #1: design, analysis		10:35	1:00	11:35	Advocates meet with Rud, Tang, Krist, Mennesson
Sensitivity Study Results	Shaklan	11:35	0:40	12:15	Include polarized light impact and how architectures
Lunch		12:15	0:50	13:05	
Updated science drivers - baseline, threshold	MacIntosh/Traub	13:05	0:40	13:45	Include implications on required Technical requirements
Experimental Results on unobscured aperture	Lawson	13:45	0:25	14:10	
TRL assessment - preliminary	Lawson	14:10	0:45	14:55	Include new requests to advocates
Special Topics					
Low Order WFC	Traub	14:55	0:40	15:35	The model, and the impact on science metric
Post processing	Soummer, Perrin	15:35	0:35	16:10	Status of inquiry
Break		16:10	0:15	16:25	
Reserve		16:25	0:30	16:55	
Dinner (off lab)		18:30	2:00	20:30	
<u>Agenda Item (Day #3)</u>	<u>Presenter</u>	<u>Start</u>	<u>Duration</u>	<u>End</u>	
Visitor Control, Coffee, Pastries		7:45	0:30	8:15	
Process: Next Steps					
Breakout#2: post processing, LOWFC		8:15	0:30	8:45	Subgroups discuss these topics, report back
Trade matrix: part 2 of 2	Blackwood	8:45	1:15	10:00	Discussion of final criteria, risks
Process for assessing TRL plans and feasibility	Lawson + Kuhnert	10:00	0:45	10:45	
Break			0:15		
Mask Tolerances - open discussion	Siegler	11:00	0:30	11:30	importance, request for addtl study
TBD		11:30	0:00	11:30	
Review of Actions, Conclusion, Next Steps	Blackwood & Grady	11:30	0:30	12:00	Review of actions, plan fwd



Preparatory Telecons

ExoPlanet Exploration Program

TIME	TOPIC	PRESENTER
Thursday, August 22, 2013	Simulation instruction update and clarification	Peter Lawson
Thursday, August 29, 2013	Opening Remarks	Blackwood/Grady
	ACW#2 agenda	Blackwood/Grady
	SDT report: science analysis / figures of merit	Traub / MacIntosh
	Central wavelength - resolve question from last telecon	Lawson
Wednesday, September 04, 2013		
	Status of TFOM analysis - inputs and products	Zhao
	Experimental Results - SPIE summary	Lawson
	TRL definitions to be used for evaluation, comparison	Lawson
	The AFTA pupil	Content, Dooley
Friday, September 13, 2013	Optical design - one example	Rud
	Analysis result - example	Krist
	HCIT schedule for future TRL advancement	Siegler/Kuhnert
	LOWFC part 1	Traub
Wednesday, September 18, 2013	LOWFC part 2	Traub